

Claims

1. A distributed computer system comprising a plurality of computers:
wherein said computers store data items, each data item being assigned to one of a plurality of
5 virtual directories;
wherein each computer that has a said data item stored thereon has at least one node of a virtual
network for directory look-up, said node comprising
- data identifying that one of the plurality of virtual directories with which the node is
associated;
 - 10 - linking data comprising addresses of other such nodes; and
 - software operable;
 - (a) in response to an enquiry message identifying another of the virtual directories
to forward the message to another node of the network;
 - (b) in response to an enquiry message identifying the virtual directory with which
15 the node is associated to generate a reply message identifying the computer;
- wherein each computer that has a said data item stored thereon has, for each item stored thereon, a
node of a virtual network for item look-up, said node comprising
- data identifying the item with which the node is associated
 - linking data comprising addresses of other such nodes each associated with an item
20 assigned to the same virtual directory, whereby said linking data together define a plurality
of virtual networks for item look-up, each of which networks corresponds to a respective
different virtual directory;
 - software operable
 - (a) in response to an enquiry message identifying another of the items to forward
25 the message to another node of the network;
 - (b) in response to an enquiry message identifying the item with which the node is
associated to generate a reply message including the item;
- wherein at least one computer has retrieval means responsive to receipt of a query identifying a
directory and an item within that directory to
- 30 (i) send to a node of the virtual network for directory look-up an enquiry message
identifying the directory;
 - (ii) upon receipt of a reply message thereto, to send to the computer identified in
the reply message an enquiry message identifying the item;
 - (iii) to receive the reply message containing the item.

2. A distributed computer system comprising a plurality of computers:
wherein said computers store data items, each data item being assigned to one of a plurality of
5 virtual directories;
wherein each computer that has a said data item stored thereon has at least one node of a virtual
network for directory look-up, said node comprising
- data identifying that one of a plurality of the virtual directories with which the node is
associated;
 - 10 - linking data comprising addresses of other such nodes; and
-software operable;
 - (a) in response to an enquiry message identifying another of the virtual directories
to forward the message to another node of the network;
 - (b) in response to an enquiry message identifying the virtual directory with which
15 the node is associated to generate a reply message identifying the computer;
- wherein each computer that has a said data item stored thereon has, for each item stored thereon, a
node of a virtual network for item look-up, said node comprising
- data identifying the item with which the node is associated
 - linking data comprising addresses of other such nodes each associated with an item
20 assigned to the same virtual directory, whereby said linking data together define a plurality
of virtual networks for item look-up, each of which networks corresponds to a respective
different virtual directory;
 - software operable
 - (a) in response to an enquiry message identifying another of the items to forward
25 the message to another node of the network;
 - (b) in response to an enquiry message identifying the item with which the node is
associated to generate a reply message identifying the computer;
 - (c) in response to an request message identifying the item with which the node is
associated to generate a reply message including the item;
- 30 wherein at least one computer has retrieval means responsive to receipt of a query
identifying a directory and an item within that directory to
- (i) send to a node of the virtual network for directory look-up an enquiry message
identifying the directory;

(ii) upon receipt of a reply message thereto, to send to the computer identified in the reply message an enquiry message identifying the item;

(iii) upon receipt of a reply message thereto, to send to the computer identified in the reply message a message requesting the item.

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3. A computer system according to claim 1 or 2 in which the or each computer having retrieval means includes also secondary retrieval means operable:

(a) upon receipt of a reply message identifying a computer having one or more items in a particular directory to identify further computers having one or more items in that directory; and

10 (b) to create a list of items in that directory.

4. A computer system according to claim 3, wherein each computer that has a said data item stored thereon also has at least one node of a secondary virtual network for directory look-up, such that said nodes together form a respective secondary virtual network for each virtual directory,
15 wherein said node comprising a data storage area for containing a list of addresses of other nodes of the secondary virtual network that have items in the same directory and said node is responsive to enquiry messages to return a message containing the addresses of the list;
and wherein the secondary retrieval means is operable, for identifying further computers having one or more items in the directory in question, to send an enquiry message to the node identified by
20 the reply message and upon receipt of a response to iteratively send enquiry messages to addresses contained in the response to that enquiry message or as the case may be in a response to a subsequent enquiry message.

5. A computer system according to claim 1, 2, 3 or 4 wherein some of said directories are
25 assigned, as subdirectories, to another of said directories and wherein the or each computer having retrieval means includes also

- first subdirectory retrieval means responsive to input of a directory name to identify a computing node having items in at least one subdirectory assigned to that directory; and

- second subdirectory retrieval means connected to receive an address identified by the first
30 subdirectory retrieval means and operable in response thereto to identify further computing nodes having items in at least one subdirectory assigned to the same directory.

6. A computer for use in a distributed computer system comprising a plurality of computers:
wherein the computer stores data items, each data item being assigned to one of a plurality of
virtual directories;
wherein the computer has at least one node of a virtual network for directory look-up, said node
5 comprising
- data identifying that one of the plurality of virtual directories with which the node is
associated;
 - linking data comprising addresses of other such nodes; and
 - software operable;
- 10 (a) in response to an enquiry message identifying another of the virtual directories
to forward the message to another node of the network;
- (b) in response to an enquiry message identifying the virtual directory with which
the node is associated to generate a reply message identifying the computer;
- wherein the computer has, for each item stored thereon, a node of a virtual network for item look-
15 up, said node comprising
- data identifying the item with which the node is associated
 - linking data comprising addresses of other such nodes each associated with an item
assigned to the same virtual directory, whereby said linking data together define a plurality
of virtual networks for item look-up, each of which networks corresponds to a respective
20 different virtual directory;
 - software operable
- (a) in response to an enquiry message identifying another of the items to forward
the message to another node of the network;
- (b) in response to an enquiry message identifying the item with which the node is
25 associated to generate a reply message including the item;
- wherein the computer has retrieval means responsive to receipt of a query identifying a
directory and an item within that directory to
- (i) send to a node of the virtual network for directory look-up an enquiry message
identifying the directory;
 - 30 (ii) upon receipt of a reply message thereto, to send to the computer identified in
the reply message an enquiry message identifying the item;
 - (iii) to receive the reply message containing the item.

7. A computer for use in a distributed computer system comprising a plurality of computers:
wherein the computer stores data items, each data item being assigned to one of a plurality of
virtual directories;
wherein the computer has at least one node of a virtual network for directory look-up, said node
5 comprising
- data identifying that one of a plurality of the virtual directories with which the node is
associated;
 - linking data comprising addresses of other such nodes; and
 - software operable;
- 10 (a) in response to an enquiry message identifying another of the virtual directories
to forward the message to another node of the network;
- (b) in response to an enquiry message identifying the virtual directory with which
the node is associated to generate a reply message identifying the computer;
- wherein the computer has, for each item stored thereon, a node of a virtual network for item look-
15 up, said node comprising
- data identifying the item with which the node is associated
 - linking data comprising addresses of other such nodes each associated with an item
assigned to the same virtual directory, whereby said linking data together define a plurality
of virtual networks for item look-up, each of which networks corresponds to a respective
20 different virtual directory;
 - software operable
- (a) in response to an enquiry message identifying another of the items to forward
the message to another node of the network;
- (b) in response to an enquiry message identifying the item with which the node is
25 associated to generate a reply message identifying the computer;
- (c) in response to a request message identifying the item with which the node is
associated to generate a reply message including the item;
- wherein the computer has retrieval means responsive to receipt of a query identifying a
directory and an item within that directory to
- 30 (i) send to a node of the virtual network for directory look-up an enquiry message
identifying the directory;
- (ii) upon receipt of a reply message thereto, to send to the computer identified in
the reply message an enquiry message identifying the item;
- (iii) upon receipt of a reply message thereto, to send to the computer identified in
35 the reply message a message requesting the item.

8. A computer according to claim 6 or 7 including also secondary retrieval means operable:
- (a) upon receipt of a reply message identifying a computer having one or more items in a particular directory to identify further computers having one or more items in that directory; and
- 5 (b) to create a list of items in that directory.

9. A computer system according to claim 6, 7 or 8 wherein some of said directories are assigned, as subdirectories, to another of said directories and wherein the computer includes also
- first subdirectory retrieval means responsive to input of a directory name to identify a computing
- 10 node having items in at least one subdirectory assigned to that directory; and
- second subdirectory retrieval means connected to receive an address identified by the first subdirectory retrieval means and operable in response thereto to identify further computing nodes having items in at least one subdirectory assigned to the same directory.

- 15 10. A computer according to claim 9 in which the retrieval means is operable to compile a composite list of said subdirectories.

11. A distributed computer system comprising a plurality of computing nodes, wherein each computer stores data items, each data item being assigned to one of a plurality of virtual
- 20 directories;
- the network having
- first retrieval means responsive to input of a directory name to identify a computing node having items in that directory;
- second retrieval means connected to receive an address identified by the first retrieval means and
- 25 operable in response thereto to identify further computing nodes having items in the same directory;
- wherein each computing node having items in a given directory has associated with it a data storage area for containing addresses for other computing nodes having items in the same directory and is responsive to enquiry messages to return a message containing the addresses of the list;
- 30 and wherein the second retrieval means is operable to send an enquiry message to the node identified by the first retrieval means and upon receipt of a response to iteratively send enquiry messages to addresses contained in the response to that enquiry message or as the case may be in a

response to a subsequent enquiry message, thereby identifying a plurality of computing nodes having items in the directory in question.

12. A distributed computer system according to claim 11 in which the retrieval means is operable to retrieve from each of said identified plurality of computing nodes a list of items stored thereon, and to compile a composite list of said items.

13. A distributed computer system comprising a plurality of computing nodes, wherein each computer stores data items, each data item being assigned to one of a plurality of virtual directories, some of said directories being assigned, as subdirectories, to another of said directories; the network having

- first retrieval means responsive to input of a directory name to identify a computing node having items in at least one subdirectory assigned to that directory;
- second retrieval means connected to receive an address identified by the first retrieval means and operable in response thereto to identify further computing nodes having items in at least one subdirectory assigned to the same directory;

wherein each computing node having items in at least one subdirectory assigned to a given directory has associated with it a data storage area for containing addresses for other computing nodes having items in at least one subdirectory assigned to the same directory and is responsive to enquiry messages to return a message containing the addresses of the list;

and wherein the second retrieval means is operable to send an enquiry message to the node identified by the first retrieval means and upon receipt of a response to iteratively send enquiry messages to addresses contained in the response to that enquiry message or as the case may be in a response to a subsequent enquiry message, thereby identifying a plurality of computing nodes having items in subdirectories of the directory in question.

14. A distributed computer system according to claim 13 in which the retrieval means is operable to compile a composite list of said subdirectories.

15. A computer system according to claim 11 or 12 wherein some of said directories are assigned, as subdirectories, to another of said directories and wherein the or each computer having retrieval means includes also

- first subdirectory retrieval means responsive to input of a directory name to identify a computing node having items in at least one subdirectory assigned to that directory; and

- second subdirectory retrieval means connected to receive an address identified by the first subdirectory retrieval means and operable in response thereto to identify further computing nodes having items in at least one subdirectory assigned to the same directory.

5 16. A computer network according to any one of claims 11 to 15 in which the first retrieval means is formed by a primary network of virtual nodes, each node being defined by a list of links to other nodes of the secondary network, each entry in the list including a label and address of the respective other node; and wherein each node includes means responsive to receipt of a request message containing a label to propagate the request message within the network and means
10 responsive to receipt of a request message containing a label matching the label of the node receiving it to generate a reply message.

17. A computer network according to any one of claims 11 to 16 in which the second
15 retrieval means is formed by a secondary network of virtual nodes, each node being defined by a list of links to other nodes of the primary network, each entry in the list including an address of the respective other node; and wherein each node includes means responsive to receipt of a request message to generate a reply message containing the addresses of the list.

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18. A computer network according to claim 17 when dependent on claim 16 in which the reply message generated by a node of the primary network includes the address of that node of the secondary network which is associated with the node generating the reply message.

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19. A computer network according to claim 17 when dependent on claim 16, or according to claim 4, wherein:

each node of the primary network includes means operable to initiate and to propagate exploratory messages each containing the label and address of the initiating node of the primary network;

30 each node is operable upon receipt of an exploratory message containing a label matching that of the receiving node and an address not matching that of the receiving node to generate a notification message for addition of a link to the secondary network, said notification message identifying the node initiating the exploratory message and containing the address of the node of the secondary network associated with the receiving node.

20. A computer network according to claim 19, in which the notification message contains, as destination, the address of the initiating node, and the initiating node is operable upon receipt thereof to forward to the node of the secondary network associated with the initiating node a message requesting addition of a link between it and the node having the address contained in the notification message.

21. A computer network according to any one of claims 10 to 20 in which each node of the secondary network includes processing means programmed to perform the following operations:
- receiving messages;
 - responding to messages requesting information about the contents of the list;
 - complying with received requests to remove an address from the list and insertion of another address into the list; and
 - in response to receipt of a message requesting a link between the node and a second node:
 - (A) generating a message to the second node requesting information about the contents of its list;
 - (B) determining whether both the first node and second node has in each case a number of addresses in its list which is less than the predetermined number;
 - (C) in the event that this condition is satisfied, inserting into its list the address of the second node and generating a message to the second node requesting the second node to add to its list the address of the node;
 - (D) in the event that this condition is not satisfied, determining whether the node has a number of addresses in its list which is at least two less than the predetermined number, and if so –
 - (a) selecting from the list of the second node the address of a third node;
 - (b) inserting the address of the second node into the list of the first node and inserting the address of the third node into the list of the first node;
 - (c) generating a message to the second node requesting the removal of the address of the third node from the list of the second node and insertion of the address of the node; and
 - (d) generating a message to the third node requesting the removal of the address of the second node from the list of the third node and insertion of the address of the node.